CLAIMS

What is claimed is:

1. An optical cross-connect switch comprising:

an optical switch fabric of optical switches to switch optical signals from one optical network connection to another optical network connection; and,

an optical-electrical-optical converter (O/E/O) coupled between the optical switch fabric and the one optical network connection or the another optical network connection, the optical-electrical-optical converter to convert an incoming optical signal into an electrical signal and the electrical signal into a regenerated optical signal.

2. The optical cross-connect switch of claim 1 wherein,

the optical-electrical-optical converter (O/E/O) is included in one or more port cards to couple to the one optical network connection or the another optical network connection.

3. The optical cross-connect switch of claim 1 wherein,

the electrical signal generated by the optical-electrical-optical converter to regenerate optical signals of a channel connection provided by the optical cross-connect switch.

4. The optical cross-connect switch of claim 1 wherein,

the electrical signal generated by the optical-electrical-optical converter to monitor optical signals of a channel connection provided by the optical cross-connect switch.

5. The optical cross-connect switch of claim 1 wherein,

the at least one of the one or more port cards including an optical-electrical-optical converter is a smart port card.

6. The optical cross-connect switch of claim 5 wherein,

at least another one of the one or more port cards does not include an optical-

electrical-optical converter and is coupled between the optical switch fabric and the one optical network connection or the another optical network connection, the at least another one of the one or more port cards not including an optical-electrical-optical converter is a passive port card.

7. The optical cross-connect switch of claim 6 wherein,
one or more smart port cards are tiered with one or more passive port cards in the optical cross-connect switch and wherein
the one or more smart port cards couple to the one or more passive port cards and the one optical network connection or the another optical network connection and
the one or more passive port cards tiered with the one or more smart port cards couple to the optical switch fabric.

8. The optical cross-connect switch of claim 6 wherein,
the smart port cards provide the regeneration of optical signals and the passive port cards provide the connection to the optical switch fabric.

9. The optical cross-connect switch of claim 8 wherein,
the smart port cards additionally monitor the optical signals.

10. The optical cross-connect switch of claim 1 wherein,
the optical-electrical-optical converter is in the input path of the at least one of the one or more port cards including an optical-electrical-optical converter.

11. The optical cross-connect switch of claim 1 wherein,
the optical-electrical-optical converter is in the output path of the at least one of the one or more port cards including an optical-electrical-optical converter.

12. The optical cross-connect switch of claim 1 wherein,
the one or more port cards including an optical-electrical-optical converter have the optical-electrical-optical converter on the input side of the optical cross-connect switch.

13. The optical cross-connect switch of claim 1 wherein,
the one or more port cards including an optical-electrical-optical converter have the optical-electrical-optical converter on the output side of the optical cross-connect switch.

14. The optical cross-connect switch of claim 1 wherein,
the optical-electrical-optical converter includes
an optical-electrical converter (O/E) and
an electrical-optical converter (E/O).

15. The optical cross-connect switch of claim 14 wherein,
the optical-electrical converter (O/E) is an optical receiver to receive an optical signal and convert it into an electrical signal.

16. The optical cross-connect switch of claim 15 wherein,
the optical receiver is a photodetector.

17. The optical cross-connect switch of claim 15 wherein,
the optical receiver to receive optical signals having a range of wavelengths.

18. The optical cross-connect switch of claim 14 wherein,
the electrical-optical converter (E/O) is an optical transmitter to receive an electrical signal and convert it into an optical signal.

19. The optical cross-connect switch of claim 18 wherein,
the electrical-optical converter (E/O) is a semiconductor laser.

20. The optical cross-connect switch of claim 14 wherein,
the electrical-optical converter (E/O) is a tunable optical transmitter to receive an electrical signal and convert it into an optical signal having a desired wavelength.

21. The optical cross-connect switch of claim 20 wherein,
the electrical-optical converter (E/O) is a multimode semiconductor laser that is tunable to the desired wavelength.

22. A method of regenerating optical signals in an all-optical cross-connect switch, the method comprising:
providing one or more smart port cards, each of the one or more smart port cards including an optical-electrical-optical converter in an optical path, the optical-electrical-optical converter to convert an input optical signal into an electrical signal and the electrical signal into an output optical signal, the output optical signal being responsive to the input optical signal;
providing one or more passive port cards, the one or more passive port cards without an optical-electrical-optical converter; and
generating an optical path through an optical switch fabric of optical switches for optical signals to flow between the one or more smart port cards and the one or more passive port cards.

23. The method of claim 22 wherein
the optical-electrical-optical converter is in the input optical path of each of the one or more smart port cards; and
the generating of the optical path through the optical switch fabric couples the input optical path of the smart port cards to the output optical path of the passive port cards.

24. The method of claim 22 wherein
the optical-electrical-optical converter is in the output optical path of each of the one or more smart port cards; and
the generating of the optical path through the optical switch fabric couples the input optical path of the passive port cards to the output optical path of the smart port cards.

25. The method of claim 22 wherein

the optical-electrical-optical converter monitors the optical signal.

26. A data communication network comprising:

an optical cross-connect switch including

an optical switch fabric of optical switches to switch optical signals from one optical network connection to another optical network connection, and

an optical-electrical-optical converter coupled between the optical switch fabric and the one optical network connection or the another optical network connection, the optical-electrical-optical converter to convert an incoming optical signal into an electrical signal and the electrical signal into an outgoing optical signal, the incoming optical signal and the outgoing optical signal being substantially similar;

and

attached network equipment coupled to the optical cross-connect switch, the attached network equipment coupled to the one or more port cards to bi-directionally transport optical signals there-between.

27. The data communications network of claim 26 wherein

the optical-electrical-optical converter is included in one or more port cards to couple to the one optical network connection and the another optical network connection.

28. The data communications network of claim 26 wherein

the optical-electrical-optical converter monitors an incoming optical signal into the optical cross-connect switch.

29. The data communications network of claim 26 wherein

the optical-electrical-optical converter monitors an outgoing optical signal from the optical cross-connect switch.

30. The data communications network of claim 26 wherein

the optical-electrical-optical converter to regenerate a switched optical input signal from the optical switch fabric into an optical output signal. .

31. The data communications network of claim 26 wherein the optical-electrical-optical converter to regenerate an optical input signal input into the optical cross-connect switch into a routable optical signal for routing through the optical switch fabric.

32. A method of bridging optical signals in optical network equipment, the method comprising:

receiving an optical signal;

splitting the optical signal into at least two similar optical signals;

processing the at least two similar optical signals in the optical network equipment; and

selecting one of at least two outputs of the optical network equipment that has a resultant optical output signal responsive to the processing of one of the at least two similar optical signals in the optical network equipment.

33. The method of claim 32 wherein the optical network equipment is an optical cross-connect switch and the processing of the at least two similar optical signals therein includes routing the at least two similar optical signals respectively over at least two optical paths to the at least two outputs.

34. The method of claim 32 wherein one of the at least two outputs of the optical network equipment has failed and another of the at least two outputs is selected that has the resultant output responsive to the processing.

35. The method of claim 32 wherein the splitting of the optical signal into the at least two similar optical signals and the processing of the at least two similar optical signals in the optical network equipment provides redundancy to increase reliability of the optical network equipment.

36. The method of claim 32 further comprising
prior to the splitting of the optical signal into the at least two similar optical signals, converting the optical signal into an electrical signal.

37. The method of claim 32 further comprising
converting the resultant optical output signal into an electrical signal.

38. The method of claim 37 further comprising
converting the electrical signal into an optical output signal from the optical network equipment.

39. An apparatus for bridging optical signals in optical network equipment comprising:
a splitter to split an input optical signal into the optical network equipment into two similar optical signals;
the optical network equipment to similarly process the two similar optical signals into two similar resultant optical output signals at two outputs if no failure exists; and
a switch to select one of the two outputs having a resultant optical output signal as the output optical signal from the optical network equipment.

40. The apparatus of claim 39 wherein
the optical network equipment is an optical cross-connect switch and the similar process of the two similar optical signals therein includes routing the two similar optical signals respectively over two optical paths to the two outputs.

41. The apparatus of claim 39 wherein
one of the two outputs of the optical network equipment is faulty and the other one of the two outputs is selected by the switch that has the resultant optical output signal as the output optical signal from the optical network equipment.

42. The apparatus of claim 39 wherein
the splitter and the optical network equipment provide redundancy for the input optical signal in generating the output optical signal to increase reliability of the optical network equipment.

43. The apparatus of claim 39 wherein
the splitter is an optical splitter.

44. The apparatus of claim 43 further comprising
an optical-electrical-optical converter to convert the input optical signal into an electrical signal and the electrical signal into an optical signal.

45. The apparatus of claim 44 wherein
the optical-electrical-optical converter and the optical splitter are in an input path of a smart port card of the optical network equipment.

46. The apparatus of claim 39 further comprising
an optical-electrical converter to convert the input optical signal into an electrical signal, and wherein the splitter includes
a first electrical-optical converter coupled to the optical-electrical converter, the first electrical-optical converter to convert the electrical signal into one of the two similar optical signals, and
a second electrical-optical converter coupled to the optical-electrical converter, the second electrical-optical converter to convert the electrical signal into another one of the two similar optical signals.

47. The apparatus of claim 39 wherein
the switch is an optical switch.

48. The apparatus of claim 47 further comprising
an optical-electrical-optical converter coupled to the optical switch, the optical-

electrical-optical converter to convert the resultant optical output signal into an electrical signal and the electrical signal into the output optical signal from the optical network equipment.

49. The apparatus of claim 48 wherein

the optical-electrical-optical converter and the optical switch are in an output path of a smart port card of the optical network equipment.

50. The apparatus of claim 39 wherein

the switch includes

a first optical-electrical converter to convert one of the two resultant output signals into a first electrical signal,

a second optical-electrical converter to convert another one of the two resultant output signals into a second electrical signal,

a multiplexer coupled to the first optical-electrical converter to receive the first electrical signal and to the second optical-electrical converter to receive the second electrical signal, the multiplexer to select between the first electrical signal and the second electrical signal as its output electrical signal, and

an electrical-optical converter coupled to the multiplexer to receive the output electrical signal, the electrical-optical converter to convert the output electrical signal into the output optical signal of the optical network equipment.

51. A data signal propagation in an optical network equipment for increased reliability, comprising:

a data signal embodied in a first optical signal on a first optical path in the optical network equipment;

the data signal embodied in a second optical signal on a second optical path in the optical network equipment;

wherein the first optical signal and the second optical signal are substantially similar; and

wherein the first optical path is different from the second optical path.

52. The data signal propagation of claim 51 wherein

if the first optical path should fail, the second optical path provides continued data signal propagation in the optical network equipment.

53. The data signal propagation of claim 51 further comprising:

the data signal embodied in a third optical signal on a third optical signal path in the optical network equipment;

wherein the third optical signal is substantially similar to the first and second optical signals; and

wherein the third optical path differs from the first and second optical paths.

54. The data signal propagation of claim 53 wherein

if the first and second optical paths should fail, the third optical path provides continued data signal propagation in the optical network equipment.

55. The data signal propagation of claim 53 further comprising:

the data signal embodied in a fourth optical signal on a fourth optical signal path in the optical network equipment;

wherein the fourth optical signal is substantially similar to the first, second and third optical signals; and

wherein the fourth optical path differs from the first, second and third optical paths.

56. The data signal propagation of claim 55 wherein

if the first, second and third optical paths should fail, the fourth optical path provides continued data signal propagation in the optical network equipment.

57. The data signal propagation of claim 51 wherein

the optical network equipment is an optical bridge, an optical router, an optical cross-connect switch, an optical hub, an optical node, an optical concentrator, or other networking equipment accepting a data signal embodied in an optical signal.

58. A method of increasing reliability in optical network equipment, the method comprising:

converting an input optical signal in the optical domain into an electrical signal in the electrical domain;

converting the electrical signal in the electrical domain into a first optical signal and a second optical signal in the optical domain, the first and second optical signals being substantially similar;

processing the first optical signals and the second optical signal similarly through the optical network equipment to generate a first processed optical signal and a second processed optical signal respectively; and

selecting either the first processed optical signal or the second processed optical signal as the output optical signal of the optical network equipment.

59. The method of claim 58 wherein

the converting of the input optical signal in the optical domain into the electrical signal in the electrical domain and the converting of the electrical signal in the electrical domain into the first optical signal and the second optical signal in the optical domain are performed substantially at the same time.

60. The method of claim 58 wherein

the optical network equipment is an optical cross-connect switch and the processing of the first and second optical signals similarly therein includes routing the first and second optical signals respectively over two differing optical paths in the optical cross-connect switch.

61. The method of claim 58 wherein

the selecting selects the first processed optical signal as the output optical signal.

62. The method of claim 61 wherein

the second processed optical signal has bit errors.

63. The method of claim 61 wherein

the second processed optical signal is unavailable for selection by the selecting as a result of the processing of the second optical signal failing to generate the second

processed optical signal.

64. The method of claim 61 wherein
the second processed optical signal is unavailable for selection by the selecting as a result of a failed component in the optical network equipment.

65. The method of claim 58 wherein
the selecting of either the first processed optical signal or the second processed optical signal includes
converting the first processed optical signal in the optical domain into a first processed electrical signal in the electrical domain,
converting the second processed optical signal in the optical domain into a second processed electrical signal in the electrical domain,
selecting either the first processed electrical signal or the second processed electrical signal as an output electrical signal, and
converting the output electrical signal in the electrical domain into the output optical signal in the optical domain.

66. An optical cross-connect switch comprising:
a first optical switch fabric of optical switches to switch optical signals from one optical network connection to another optical network connection;
a second optical switch fabric of optical switches to switch optical signals from the one optical network connection to the another optical network connection; and,
an optical-electrical-optical converter (O/E/O) coupled between the first and second optical switch fabrics and the one optical network connection or the another optical network connection, the optical-electrical-optical converter to convert an incoming optical signal into an electrical signal and the electrical signal into an outgoing optical signal, the incoming optical signal and the outgoing optical signal being substantially similar.

67. The optical cross-connect switch of claim 66 wherein,
the optical-electrical-optical converter is included in one or more port cards to couple to the one optical network connection and the another optical network

connection.

68. The optical cross-connect switch of claim 66 wherein,
the optical switches in the first optical switch fabric and the second optical switch fabric are micro-machined mirrors to direct the optical signals from the one optical network connection to the another optical network connection.

69. The optical cross-connect switch of claim 66 wherein,
the electrical signal generated by the optical-electrical-optical converter is for regeneration of optical signals over a channel connection provided by the optical cross-connect switch.

70. The optical cross-connect switch of claim 66 wherein,
the at least one of the one or more port cards including an optical-electrical-optical converter is a smart port card.

71. The optical cross-connect switch of claim 70 wherein,
at least another one of the one or more port cards is a test monitoring port card, the test monitoring port card including an optical switch and an optical-electrical converter, the optical switch to receive a first optical signal and a second optical signal respectively from the first and second optical switch fabrics, the optical switch to select between the first and second optical signals respectively for testing as the test optical signal, the optical switch coupled to the optical-electrical converter to convert the selected test optical signal into a test electrical signal for monitoring by the optical cross-connect switch.

72. The optical cross-connect switch of claim 70 wherein,
at least another one of the one or more port cards is an active test port card, the active test port card including an optical switch, an optical-electrical converter and an electrical-optical converter, the electrical-optical converter to receive and convert an electrical testing signal into an optical testing signal and couple it into the first or second optical switch fabric to test the first or second optical switch fabric, the optical switch to receive a first optical signal or a second optical signal respectively from the

first or second optical switch fabrics responsive to the optical testing signal, the optical switch to select between the first or second optical signals responsive to the coupling of the optical testing signal into the first or second optical switch fabric respectively as the resultant test optical signal, the optical switch coupled to the optical-electrical converter to convert the resultant test optical signal into a resultant test electrical signal for monitoring by the optical cross-connect switch.

73. The optical cross-connect switch of claim 66 wherein,

the optical-electrical-optical converter is in the input path of the at least one of the one or more port cards including an optical-electrical-optical converter.

74. The optical cross-connect switch of claim 66 wherein,

the optical-electrical-optical converter is in the output path of the at least one of the one or more port cards including an optical-electrical-optical converter.

75. An apparatus for bridging optical signals in optical network equipment comprising:

a splitter to split an input optical signal into the optical network equipment into two similar optical signals;

a first optical switch fabric to couple optical signals from one network connection to another network connection, the first optical switch fabric to receive one of the two similar optical signals and generate a first switched optical signal;

a second optical switch fabric to couple the optical signals from the one network connection to the another network connection, the second optical switch fabric to receive another one of the two similar optical signals and generate a second switched optical signal; and

a switch to receive the first and second switched optical signals and to select between the first switched optical signal and the second switched optical signal as the output optical signal from the optical network equipment.

76. The apparatus of claim 75 wherein

the first optical switch fabric provides one optical path for data signals of the incoming optical signal and the second optical switch fabric provides a redundant

optical path for data signals of the incoming optical signal.

77. The apparatus of claim 75 wherein
either one of the first and second switched optical signals is faulty and the other one is selected by the switch as the output optical signal from the optical network equipment.

78. The apparatus of claim 75 wherein
the splitter is a passive splitter.

79. The apparatus of claim 75 wherein
the splitter is an optical splitter.

80. The apparatus of claim 75 further comprising
an optical-electrical-optical converter coupled to the splitter, the optical-electrical-optical converter to convert the input optical signal into an electrical signal and the electrical signal into a regenerated optical signal to couple into the splitter as the input optical signal.

81. The apparatus of claim 80 wherein
the electrical signal to provide monitoring of the input optical signal.

82. The apparatus of claim 80 wherein
the optical-electrical-optical converter and the splitter are in an input path of a smart port card of the optical network equipment.

83. The apparatus of claim 75 further comprising
an optical-electrical converter to convert the input optical signal into an electrical signal, and wherein the splitter couples one of the two similar optical signals into the first optical switch fabric and the other one of the two similar optical signals into the second optical switch fabric, the splitter including
a first electrical-optical converter coupled to the optical-electrical converter, the

first electrical-optical converter to convert the electrical signal into one of the two similar optical signals, and

a second electrical-optical converter coupled to the optical-electrical converter, the second electrical-optical converter to convert the electrical signal into another one of the two similar optical signals.

84. The apparatus of claim 75 wherein
the switch is a passive switch.

85. The apparatus of claim 75 wherein
the switch is an optical switch.

86. The apparatus of claim 85 further comprising
an optical-electrical-optical converter coupled to the optical switch, the optical-electrical-optical converter to convert the optical output signal into an electrical signal and the electrical signal into an output optical signal to output from the optical network equipment as the optical output signal.

87. The apparatus of claim 86 wherein
the optical-electrical-optical converter and the optical switch are in an output path of a smart port card of the optical network equipment.

88. The apparatus of claim 75 wherein
the switch includes
a first optical-electrical converter to convert the first switched optical signal into a first electrical signal,
a second optical-electrical converter to convert the first switched optical signal into a second electrical signal,
a multiplexer coupled to the first optical-electrical converter to receive the first electrical signal and to the second optical-electrical converter to receive the second electrical signal, the multiplexer to select between the first electrical signal and the second electrical signal as its output electrical signal, and
an electrical-optical converter coupled to the multiplexer to receive the output

electrical signal, the electrical-optical converter to convert the output electrical signal into the output optical signal of the optical network equipment, the output electrical signal for monitoring the output optical signal of the optical network equipment.

89. A method of bridging optical signals in an optical cross-connect switch to increase reliability, the method comprising:

receiving an optical signal;

splitting the optical signal into two similar optical signals;

coupling one of the two similar optical signals into a first optical switch fabric and the another one of the two similar optical signals into a second optical switch fabric;

routing the two similar optical signals over optical paths respectively in the first optical switch fabric and the second optical switch fabric to two outputs; and

selecting one of the two similar optical signals at the two outputs as an optical output signal of the optical cross-connect switch.

90. The method of claim 89 wherein

one of the two similar optical signals has failed to reach a respective one of the two outputs and the other of the two outputs is selected by the selecting which has the other of the two similar optical signals present.

91. The method of claim 89 further comprising

prior to the splitting of the optical signal into the two similar optical signals, converting the optical signal into an electrical signal.

92. The method of claim 89 further comprising

converting the optical output signal into an electrical signal for monitoring.

93. The method of claim 92 further comprising

converting the electrical signal into an optical signal to be output as the output optical signal from the optical network equipment.

94. An apparatus for regenerating optical signals in an all-optical cross-

connect switch, the apparatus comprising:

a smart port card, the smart port card including

an optical-electrical-optical converter in an optical path, the optical-electrical-optical converter to convert an input optical signal into an electrical signal and the electrical signal into an output optical signal.

95. The apparatus of claim 94 wherein

the output optical signal is substantially similar to the input optical signal.

96. The apparatus of claim 94 wherein

the optical-electrical-optical converter provides wavelength conversion such that the output optical signal has substantially similar information content as that of the input optical signal but a differing photonic wavelength.

97. The apparatus of claim 94 wherein

the optical-electrical-optical converter is in the input optical path of the smart port card.

98. The apparatus of claim 94 wherein

the optical-electrical-optical converter is in the output optical path of the smart port card.

99. The apparatus of claim 94 wherein

the optical-electrical-optical converter provides a tap to the electrical signal to monitor the optical signal.

100. A method of regenerating optical signals in an all-optical cross-connect switch, the method comprising:

converting a first optical signal into an electrical signal;

converting the electrical signal into a second optical signal, the second optical signal being responsive to the first optical signal; and

forming an optical path through an optical switch fabric of optical switches over which optical signals can be transported through the optical cross-connect switch.

101. The method of claim 100 wherein

the converting of the first optical signal into the electrical signal and the converting of the electrical signal into the second optical signal are performed in an input optical path to the all-optical cross-connect switch.

102. The method of claim 100 wherein

the converting of the first optical signal into the electrical signal and the converting of the electrical signal into the second optical signal are performed in an output optical path from the all-optical cross-connect switch.

103. The method of claim 100 wherein

the converting of the first optical signal into the electrical signal and the converting of the electrical signal into the second optical signal regenerates the first optical signal.

104. The method of claim 100 wherein

the converting of the first optical signal into the electrical signal allows for monitoring of the first optical signal.

105. The method of claim 100 wherein,

the first optical signal has a first wavelength and the second optical signal has a second wavelength differing from the first wavelength.